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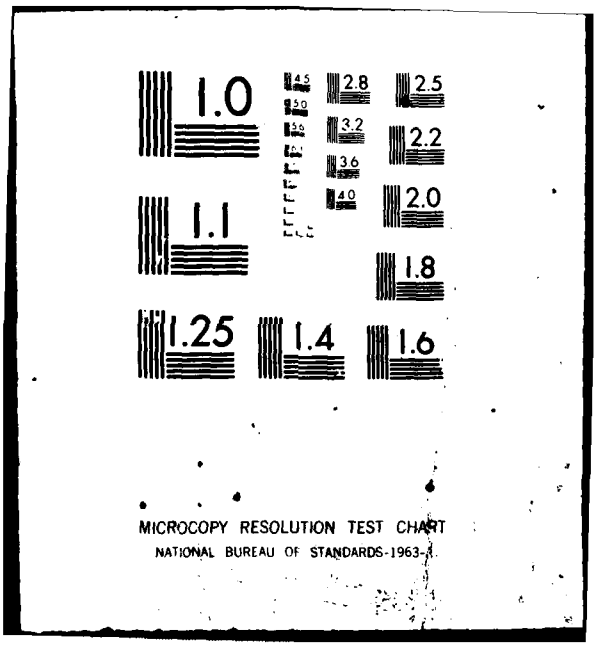
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ATOMIZATION OF A LIQUID BY SPRAY NOZZLES
(Selected pages)

By

L. A. Vitman, B. D. Katsnel'son, and I. I. Paleyev

EDITED TRANSLATION

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By: L. A. Vitman, B. D. Katsnel'son, and
I. I. Paleyev

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Table of Contents

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Block	Italic	Transliteration	Block	Italic	Transliterati
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ë in Russian, transliterate as yë or ë.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	Engl
sin	sin	sh	sinh	arc sh	sinh^{-1}
cos	cos	ch	cosh	arc ch	cosh^{-1}
tg	tan	th	tanh	arc th	tanh^{-1}
ctg	cot	cth	coth	arc cth	coth^{-1}
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

ATOMIZATION OF A LIQUID BY SPRAY NOZZLES

L. A. Vitman, B. D. Katsnel'son, and I. I. Paleyev

Editor's Introduction

The present monograph is devoted to the problem of atomization of a liquid by different types of spray nozzles, a problem which is very important for contemporary technology. The large volume of investigations carried out, the detailed analysis of a number of dependences in well-selected generalized coordinates, the striving to reduce the results obtained to a form which is suitable for direct engineer use, make this monograph valuable both for investigators and for personnel engaged in designing and operating such devices.

The quite considerable amount of material on the description of the principles of operation and the design formulation of different types of nozzles increases the practical value of the book. Although calculation methods in this area, generally speaking, are still far from completeness, such a major section of the book as the hydrodynamic calculation of atomization under "cold" conditions is reduced to totally engineering methods and is illustrated with clear examples.

As concerns the calculations of the burning of individual drops, and, moreso, the atomized spray, then they have basically a qualitative nature. However, these materials are absolutely necessary for a correct qualitative representation of the process of combustion of liquid fuel and can, to a certain extent, serve for appraisal quantitative calculations.

S. Kutateladze

Authors' Introduction

Atomization ("crushing") of a liquid is used extensively in modern technology. It is carried out, in particular, in the chemical and food industries in the extraction of solid substances from liquids, in drying, in different interactions between liquids and gases, and also in a number of other technological processes (crushing of pulp in the aluminum industry, cooling of gases with an atomized liquid in a number of devices, etc.). Such a widespread application of atomization is explained by the fact that in all these processes a reduction in the dimensions of the drops sharply raises the coefficient of heat transfer, and, consequently, reduces the time for the flow of the process, which makes it possible to cut down considerably the size of the equipment. Furthermore, atomization ensures a greater uniformity of distribution of liquid and its better interaction with the reacting medium.

The uniform distribution of liquid and economy of the dispersed material ensured the success of the principle of fine atomization of dyestuffs in the construction and other branches of industry. Atomizers found considerable application in the spraying of plants in the agriculture industry. The leaves of plants on hundreds of thousands of hectares are covered annually by the fine drops of special chemical compositions, intended for combatting the pests of farm crops. In all these cases spray nozzles are used which are adapted for the fine and as much as possible uniform distribution of the liquid over the cross section of the jet.

The principle of atomization is realized widely in the combustion of liquid fuel. Liquid fuel is burned in the furnaces of steam boilers, combustion chambers of gas turbines, industrial ovens, internal combustion engines, and other devices. Depending on the purpose and design of the aggregate this or that kind of liquid fuel is used: gasoline, ligroin, kerosene, solar oil and mazut. All these types of fuel are obtained from petroleum. The increase in petroleum production in the USSR is evident from the figures given below:

Year	Petroleum production in the USSR, million, t
1913 (in contemporary boundaries)	10.3
1928	11.6
1935	25.2
1940	31.1
1945	19.4
1950	37.9
1955	70.8
1958	113.2
1959	129.6
1960	148.0
1961	166.0
1965 (control figures for development of the national economy of the USSR)	230-240

The considerable increase in the production of petroleum in the USSR conditioned a change in the fuel balance of the country and promoted the introduction of liquid fuel in the energy system of the country.

A considerable share of the mazut, obtained as a result of the refining of extracted petroleum, will be burned in the furnaces of steam boilers and also in industrial ovens. It is extremely important to ensure the highly economical burning of mazut in them with a high degree of forcing, which will yield a tremendous economy of fuel and make it possible to cut down the weight and dimensions of burning devices.

The methods for the burning of liquid fuel are very diverse, since they depend on the efficiency of the aggregate, its purpose and a number of other factors. For all these methods the modern technology of combustion of liquid fuel is considered a compulsory stage of atomization, since it, strengthening the heat exchange between the pulverized fuel and the gaseous medium, and improving the mixing of particles of fuel with the oxidizer, promotes the intensification of the burning process.

It has to be noted that prior to the application of atomization liquid fuel was hardly used for burning. At that time petroleum was used, as a rule, only for the obtaining of oils and certain other chemical products. Kerosene found application only for illumination. Gasoline and mazut represented undesirable products from the distilling of petroleum and often was poured off as industrial waste. The first attempt at "pulverizing" petroleum led to the development of very primitive devices, representing a set of tubes, out of which comparatively large drops escaped. These were burned in the body of the ovens. Only with the appearance of spray nozzles did the industrial application of petroleum and a number of its components as fuel begin.

The economy of burning mazut is determined to a considerable degree by the quality of its atomization. As will be evident from what follows, for the effective combustion and stable burning it is not always necessary to have as fine a spray as possible. It is necessary to have that fractional composition which would ensure the optimal conditions for the development of the process.

The tremendous importance of atomization of a liquid for the solution of a number of technical problems led to the development of a large number of designs of spray nozzles of every description. The majority of these investigations had a specific nature, pertaining only to a given specific type of spray nozzle. Together with this investigative work was carried out on the search for general regularities which could be extended not only to the type of nozzle being tested with changes in its efficiency and conditions of operation, but also to other spray nozzles operating on the same principle.

In this book the theory of atomization by mechanical and pneumatic (or steam) spray nozzles is expounded and basic calculation recommendations are given, stemming from a generalization of material and confirmed by experiments. Also considered here are atomizers which have found wide application in the heating practice of stationary steam boilers, combustion chambers of gas turbines and industrial furnaces. The material is set forth in such a manner that it can be used also in branches which use the atomizers for other purposes.

The wide range of powers of industrial furnaces, power furnaces and combustion chambers demanded consideration of spray nozzles both of low and high efficiency.

The hot-water heaters with a capacity of 500 t of steam an hour and higher which have appeared recently and the still more considerable increase in the unit power of boiler installations require the development of nozzles with a very high hourly flow-rate of fuel. Unfortunately heating technology has available very limited information on the operation of nozzles of such power. In the book data are given which, it has to be assumed, will be of help in the designing of atomizers of high efficiency.

In a separate chapter problems are considered which are connected with the development of highly-efficient devices (nozzles with preliminary gasification) for the preparation of fuel for combustion with very high volumetric and cross-section stresses. Design arrangements of such a device are also found there.

Along with shedding light on problems connected with the atomization of liquid fuel and with the designing of nozzles, a place is set aside in the book for materials on the burning of a single drop and a spray of liquid fuel. Also considered are certain principles of the designing of heating devices for steam boilers and the combustion chambers of gas turbines which are necessary for determining the required fineness of atomization and the nature of distribution of the drops of liquid fuel over the cross section of the jet.

Chapters 2, 3, 4 and 5 were written by L. A. Vitman, sections 6-1—6-4 and chapter 7 - by B. D. Katsnel'son, chapter 1, section 6-5 and chapter 10 - jointly by both authors, and chapters 8 and 9 - by I. I. Paleyev.

The material in the book was discussed by all the authors jointly and reflects their common point of view on all the problems touched upon. The authors are grateful to the reviewer of the book the honored scientist and engineer Professor G. F. Knorre for the very valuable instructions and advice given to them, which was taken into account in the final editing of the manuscript.

Remarks and requests for the book should be directed to the address: Leningrad, D-41, Marsovo field, d. 1, Leningrad Department of the Gosenergoizdat.

Table of Contents

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